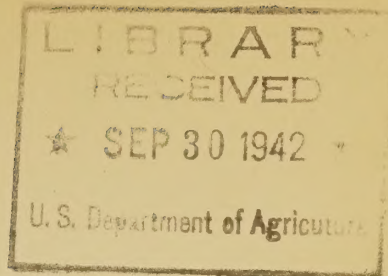


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T22



DETERMINATION OF SIZE OF SERVICE OR  
SECONDARY CONDUCTOR TO PREVENT FLICKER

by  
S. Lubin  
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U. S. DEPARTMENT OF AGRICULTURE  
RURAL ELECTRIFICATION ADMINISTRATION  
TECHNICAL STANDARDS DIVISION

DETERMINATION OF SIZE OF LEAVES OF  
SECONDARY CONDUCTOR TO PREVENT WINDING

BY  
R. L. LIND  
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BUREAU OF EXTENSION ADMINISTRATION  
TECHNICAL STANDARDS DIVISION

### SUMMARY

The selection of sufficiently large secondary or service conductors will eliminate flicker due to excessive voltage drop in these conductors when motor loads are switched into the circuit. The method outlined in this bulletin allows the determination of the minimum size of conductor when certain factors are known.



The selection of subjects for a research project is a critical step in the research process. The researcher will often select subjects who are representative of the population being studied. This selection process is often based on the researcher's knowledge of the population and the research objectives. The researcher will often select subjects who are easy to contact and who are willing to participate in the study. The researcher will also select subjects who are representative of the population being studied. The researcher will often select subjects who are representative of the population being studied. The researcher will often select subjects who are representative of the population being studied.

## DETERMINATION OF SIZE OF SERVICE OR SECONDARY CONDUCTOR TO PREVENT FLICKER

The following considerations should be taken into account in using the attached charts:

1. The values obtained from the charts are valid provided the primary regulation is sufficient to take care of the starting current. In cases where primary regulation is poor, the value of secondary supply voltage used should take into account primary voltage drop due to the starting current.
2. Since in some cases this method would require the use of service conductors or transformers of larger sizes than is usual in REA usage, some judgment should be used in its application. It should be applied only where motor loads are coincident with lighting.
3. When a current-limiting starting device is used, the value of starting current used in the calculations should be the value as limited by the starting device. A table of average starting currents and starting power factors of various types of motors is attached to this bulletin. This contains average values of motors as listed by several manufacturers and is useful when more precise data is not available.

### USE OF THE CHARTS

The following information must be on hand before the secondary size can be determined from the attached charts:

1. Number of starts per hour, minute, or second, of the motor.
2. Make and size of transformer to be used.
3. The supply voltage (E) on the secondary or service.
4. The starting current (I) of the motor.
5. Power factor of the motor at starting ( $\cos \theta$ ).
6. Length of secondary or service circuit (L).



INSTRUCTIONS TO THE JURY  
IN THE CASE OF  
THE PEOPLE OF THE STATE OF NEW YORK  
VS. JOHN J. HENRY

The following instructions should be read to the jury in the case of the People of the State of New York vs. John J. Henry.

1. The jury is sworn to try the facts of the case and to return a verdict according to the law as given to you by the court.
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3. The jury is sworn to try the facts of the case and to return a verdict according to the law as given to you by the court.
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10. The jury is sworn to try the facts of the case and to return a verdict according to the law as given to you by the court.

The general procedure is then as follows:

1. Determine the allowable percent of voltage fluctuation from Chart I.
2. Determine the percent R and percent X of the transformer from Chart II.
3. Convert the allowable percent voltage fluctuation from the transformer rating basis to the actual load basis by use of Chart III.
4. Determine the percent voltage drop in the transformer and the percent resistance drop in the secondary or service conductor from Chart IV.
5. Obtain the required conductor size or resistance in ohms per 1000 feet from Chart V.

Detailed steps are given in the following pages with each chart.







AVERAGE LINE STARTING CURRENTS AND STARTING POWER FACTORS OF MOTORS

Single-Phase

HP	Line Starting Current (Amps.)	Starting Power Factor
Condenser Start 110 Volts		
1/6	22	.75
1/4	23	.75
1/3	23	.75
220 Volts		
1/3	12	.75
1/2	16	.75
3/4	23	.75
1	30	.75
Split Phase 110 Volts		
1/8	17	.65
1/6	28	.65
1/4	29	.65
1/3	30	.65
1/2	37	.65
3/4	60	.65

HP	Line Starting Current (Amps.)	Starting Power Factor
Repulsion-Induction 110-Volts		
1/8	13	.50
1/6	13	.50
1/4	14	.50
1/3	19	.50
1/2	26	.50
3/4	38	.50
220 Volts		
1/2	14	.50
3/4	20	.50
1	25	.50
1-1/2	34	.50
2	41	.50
3	58	.50
5	95	.50
7-1/2	150	.50

Three-Phase

Squirrel Cage 110 Volts		
1/2	19	.11
3/4	29	.16
1	41	.10
1-1/2	58	.10
2	72	.11
3	105	.12
5	165	.12
7-1/2	235	.13
10	300	.13
15	415	.14
20	490	.15
25	660	.15
30	775	.15
40	1110	.14
50	1370	.14
60	1650	.14

75	2010	.15
100	2940	.14
125	3380	.15
150	4610	.13
200	6580	.12
250	7300	.14
208 Volts		
3	37	.12
5	88	.12
7-1/2	115	.13
10	155	.13
15	225	.14
20	285	.15
25	360	.15
30	410	.15
40	530	.14
50	715	.14



Year	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100
1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100	

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1850-1851

STATION	TIME	REMARKS
101	10:00	101
102	10:05	102
103	10:10	103
104	10:15	104
105	10:20	105
106	10:25	106
107	10:30	107
108	10:35	108
109	10:40	109
110	10:45	110
111	10:50	111
112	10:55	112
113	11:00	113
114	11:05	114
115	11:10	115
116	11:15	116
117	11:20	117
118	11:25	118
119	11:30	119
120	11:35	120
121	11:40	121
122	11:45	122
123	11:50	123
124	11:55	124
125	12:00	125
126	12:05	126
127	12:10	127
128	12:15	128
129	12:20	129
130	12:25	130
131	12:30	131
132	12:35	132
133	12:40	133
134	12:45	134
135	12:50	135
136	12:55	136
137	13:00	137
138	13:05	138
139	13:10	139
140	13:15	140
141	13:20	141
142	13:25	142
143	13:30	143
144	13:35	144
145	13:40	145
146	13:45	146
147	13:50	147
148	13:55	148
149	14:00	149
150	14:05	150
151	14:10	151
152	14:15	152
153	14:20	153
154	14:25	154
155	14:30	155
156	14:35	156
157	14:40	157
158	14:45	158
159	14:50	159
160	14:55	160
161	15:00	161
162	15:05	162
163	15:10	163
164	15:15	164
165	15:20	165
166	15:25	166
167	15:30	167
168	15:35	168
169	15:40	169
170	15:45	170
171	15:50	171
172	15:55	172
173	16:00	173
174	16:05	174
175	16:10	175
176	16:15	176
177	16:20	177
178	16:25	178
179	16:30	179
180	16:35	180
181	16:40	181
182	16:45	182
183	16:50	183
184	16:55	184
185	17:00	185
186	17:05	186
187	17:10	187
188	17:15	188
189	17:20	189
190	17:25	190
191	17:30	191
192	17:35	192
193	17:40	193
194	17:45	194
195	17:50	195
196	17:55	196
197	18:00	197
198	18:05	198
199	18:10	199
200	18:15	200

[illegible]



Three Phase

HP	Line Starting Current (Amps.)	Starting Power Factor
Squirrel Cage 220 Volts		
1/8	3.7	.10
1/6	4.6	.10
1/4	6.4	.10
1/3	9.6	.10
1/2	10	.11
3/4	15	.16
1	21	.10
1-1/2	31	.10
2	38	.11
3	52	.12
5	82	.12
7-1/2	120	.13
10	150	.13
15	220	.14
20	275	.15
25	355	.15
30	415	.15
40	555	.14
50	690	.14
60	865	.14
75	1050	.14
100	1500	.14
125	1800	.13
150	2390	.13
200	3290	.12
250	3650	.12
440 Volts		
1/2	4.8	.11
3/4	7.1	.16
1	10	.10
1-1/2	15	.10
2	18	.11
3	25	.12
5	41	.12
7-1/2	57	.13
10	74	.13
15	105	.14
20	130	.15
25	165	.15
30	190	.15
40	275	.14
50	345	.14
60	410	.14
75	500	.14
100	735	.14

HP	Line Starting Current (Amps.)	Starting Power Factor
125	845	.14
150	1155	.13
200	1635	.12
250	1825	.12
550 Volts		
1/2	3.8	.11
3/4	5.7	.16
1	7.9	.10
1-1/2	13	.11
2	15	.11
3	20	.12
5	36	.12
7-1/2	46	.12
10	59	.13
15	84	.14
20	105	.15
25	135	.15
30	155	.15
40	220	.14
50	290	.14
60	340	.14
75	395	.14
100	590	.14
125	675	.14
150	920	.13
200	1320	.12
250	1460	.12
2200 Volts		
30	40	.15
40	55	.14
50	68	.14
60	95	.14
75	110	.14
100	150	.14
125	195	.14
150	255	.14
200	295	.14
250	365	.14
300	475	.12

# TABLE 1

Year	Population	Area
1950	1,000,000	100,000
1951	1,050,000	105,000
1952	1,100,000	110,000
1953	1,150,000	115,000
1954	1,200,000	120,000
1955	1,250,000	125,000
1956	1,300,000	130,000
1957	1,350,000	135,000
1958	1,400,000	140,000
1959	1,450,000	145,000
1960	1,500,000	150,000
1961	1,550,000	155,000
1962	1,600,000	160,000
1963	1,650,000	165,000
1964	1,700,000	170,000
1965	1,750,000	175,000
1966	1,800,000	180,000
1967	1,850,000	185,000
1968	1,900,000	190,000
1969	1,950,000	195,000
1970	2,000,000	200,000
1971	2,050,000	205,000
1972	2,100,000	210,000
1973	2,150,000	215,000
1974	2,200,000	220,000
1975	2,250,000	225,000
1976	2,300,000	230,000
1977	2,350,000	235,000
1978	2,400,000	240,000
1979	2,450,000	245,000
1980	2,500,000	250,000
1981	2,550,000	255,000
1982	2,600,000	260,000
1983	2,650,000	265,000
1984	2,700,000	270,000
1985	2,750,000	275,000
1986	2,800,000	280,000
1987	2,850,000	285,000
1988	2,900,000	290,000
1989	2,950,000	295,000
1990	3,000,000	300,000
1991	3,050,000	305,000
1992	3,100,000	310,000
1993	3,150,000	315,000
1994	3,200,000	320,000
1995	3,250,000	325,000
1996	3,300,000	330,000
1997	3,350,000	335,000
1998	3,400,000	340,000
1999	3,450,000	345,000
2000	3,500,000	350,000
2001	3,550,000	355,000
2002	3,600,000	360,000
2003	3,650,000	365,000
2004	3,700,000	370,000
2005	3,750,000	375,000
2006	3,800,000	380,000
2007	3,850,000	385,000
2008	3,900,000	390,000
2009	3,950,000	395,000
2010	4,000,000	400,000
2011	4,050,000	405,000
2012	4,100,000	410,000
2013	4,150,000	415,000
2014	4,200,000	420,000
2015	4,250,000	425,000
2016	4,300,000	430,000
2017	4,350,000	435,000
2018	4,400,000	440,000
2019	4,450,000	445,000
2020	4,500,000	450,000

Year	Population	Area
1950	1,000,000	100,000
1951	1,050,000	105,000
1952	1,100,000	110,000
1953	1,150,000	115,000
1954	1,200,000	120,000
1955	1,250,000	125,000
1956	1,300,000	130,000
1957	1,350,000	135,000
1958	1,400,000	140,000
1959	1,450,000	145,000
1960	1,500,000	150,000
1961	1,550,000	155,000
1962	1,600,000	160,000
1963	1,650,000	165,000
1964	1,700,000	170,000
1965	1,750,000	175,000
1966	1,800,000	180,000
1967	1,850,000	185,000
1968	1,900,000	190,000
1969	1,950,000	195,000
1970	2,000,000	200,000
1971	2,050,000	205,000
1972	2,100,000	210,000
1973	2,150,000	215,000
1974	2,200,000	220,000
1975	2,250,000	225,000
1976	2,300,000	230,000
1977	2,350,000	235,000
1978	2,400,000	240,000
1979	2,450,000	245,000
1980	2,500,000	250,000
1981	2,550,000	255,000
1982	2,600,000	260,000
1983	2,650,000	265,000
1984	2,700,000	270,000
1985	2,750,000	275,000
1986	2,800,000	280,000
1987	2,850,000	285,000
1988	2,900,000	290,000
1989	2,950,000	295,000
1990	3,000,000	300,000
1991	3,050,000	305,000
1992	3,100,000	310,000
1993	3,150,000	315,000
1994	3,200,000	320,000
1995	3,250,000	325,000
1996	3,300,000	330,000
1997	3,350,000	335,000
1998	3,400,000	340,000
1999	3,450,000	345,000
2000	3,500,000	350,000
2001	3,550,000	355,000
2002	3,600,000	360,000
2003	3,650,000	365,000
2004	3,700,000	370,000
2005	3,750,000	375,000
2006	3,800,000	380,000
2007	3,850,000	385,000
2008	3,900,000	390,000
2009	3,950,000	395,000
2010	4,000,000	400,000
2011	4,050,000	405,000
2012	4,100,000	410,000
2013	4,150,000	415,000
2014	4,200,000	420,000
2015	4,250,000	425,000
2016	4,300,000	430,000
2017	4,350,000	435,000
2018	4,400,000	440,000
2019	4,450,000	445,000
2020	4,500,000	450,000



CHART I

ALLOWABLE PERCENT OF VOLTAGE FLUCTUATION

This chart shows the permissible percent of voltage fluctuation for a varying number of fluctuations (or motor starts) per unit time.

Example: A three phase  $7\frac{1}{2}$  H.P. 220 Volt motor starts 6 times per hour.

Against 6 fluctuations per hour on the curve read 3.6% allowable voltage fluctuation.

• • • • •  
• •

THAN 11

1891

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Chart I

ALLOWABLE PERCENT OF VOLTAGE FLICKER —

(Reproduced from Electrical World, Jan. 25, 1941)

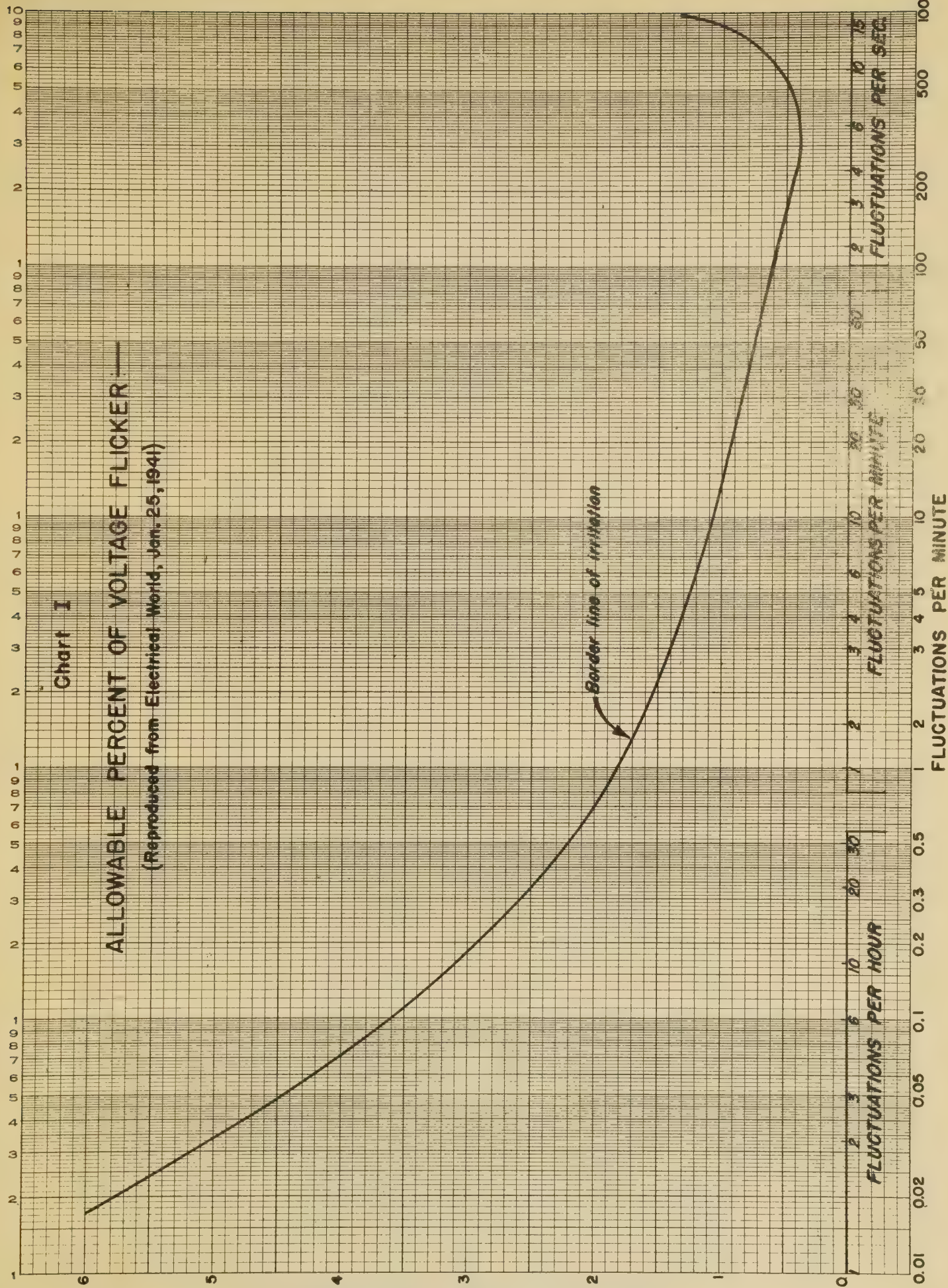
PERCENT VOLTAGE FLUCTUATION = "V"

FLUCTUATIONS PER HOUR

FLUCTUATIONS PER MINUTE

FLUCTUATIONS PER SEC.

FLUCTUATIONS PER MINUTE







# PERCENT RESISTANCE AND PERCENT REACTANCE OF DISTRIBUTION TRANSFORMERS\*

TRANSFORMER RATING (KVA.)	ALLIS CHALMERS		GENERAL ELECTRIC		KUHLMAN		LINE MATERIAL		MOLONEY		STANDARD		WAGNER		WESTING- HOUSE	
	% R <sub>T</sub>	% X <sub>T</sub>	% R <sub>T</sub>	% X <sub>T</sub>	% R <sub>T</sub>	% X <sub>T</sub>	% R <sub>T</sub>	% X <sub>T</sub>	% R <sub>T</sub>	% X <sub>T</sub>	% R <sub>T</sub>	% X <sub>T</sub>	% R <sub>T</sub>	% X <sub>T</sub>	% R <sub>T</sub>	% X <sub>T</sub>
1.5	2.37	2.08	2.60	2.19	2.86	1.87	3.06	1.48	2.73	1.67	3.06	1.90	2.25	1.31	2.87	0.88
3	2.08	2.04	2.27	2.24	2.46	1.60	2.73	1.80	2.40	1.80	2.80	1.50	2.26	1.60	2.26	1.96
5	2.25	1.79	2.20	2.18	2.22	1.91	2.50	1.99	2.42	2.10	2.57	2.44	2.20	1.99	2.00	1.32
7.5	2.00	2.21	2.15	1.79	2.27	2.33	2.27	2.25	2.27	2.34	2.33	1.72	1.81	1.69	2.08	1.88
10	1.85	2.25	2.00	1.96	2.17	2.63	2.17	2.36	2.02	2.26	1.95	2.34	1.83	2.11	1.90	1.63
15	1.53	2.24	1.72	2.21	1.78	2.82	1.78	2.66	1.82	2.87	1.82	2.48	1.65	2.29	1.68	1.65
25	1.42	2.57	1.51	2.36	1.60	3.19	1.60	2.78	1.53	3.14	1.67	2.90	1.36	2.88	1.47	2.73
37.5	1.32	2.79	1.31	2.47	1.38	3.61	1.38	2.89	1.35	2.90	1.49	2.80	1.20	2.88	1.39	3.03
50	1.16	2.91	1.22	2.52	1.04	3.80	1.34	2.91	1.38	2.96	1.34	2.90	1.08	3.30	1.29	3.37
75	1.09	2.64	1.10	2.47	1.25	3.36	1.25	4.84	1.31	3.10	1.21	3.68	1.16	3.44	1.20	4.80
100	1.13	3.07	1.12	2.46	1.23	3.46	1.23	4.84	1.24	3.10	1.26	3.80	1.07	4.41	1.22	3.96

\* Rating from 1.5 Kva. to 15 Kva. inclusive are R.E.A. type. Rating of 25 Kva. and above are conventional double bushing type.



CHART III

TO CONVERT ALLOWABLE PERCENT VOLTAGE FLUCTUATION  
from  
TRANSFORMER RATING BASE TO ACTUAL LOAD BASE

1. Use value of V from Chart I.
2. Connect V and W. Mark intersection on A.
3. Proceed from A to E. Mark intersection on W.
4. Connect W and I. Intersection on Z is allowable percent voltage fluctuation under actual load conditions.

Example: 3 - 3 Kva Kuhlman transformers are used to serve the motor in the previous example. The line starting current (from the table of starting current) is 120 amps. The phase current I is equal to  $\frac{1}{3} \times 120 = 40$  amps.

1. Connect V = 3.6% with W = 3 Kva. Mark intersection on A.
2. Proceed from A to E =  $220/1.73 = 127$  volts, phase to neutral. Mark intersection on W.
3. Connect W and I = 40 amps. Then Z = 2.0%.



1911

Received of the Treasurer of the  
Board of Directors of the  
City of New York

the sum of \$100.00

for the year 1911

in full for the year 1911

for the year 1911

and for the year 1911

for the year 1911

for the year 1911

for the year 1911

for the year 1911

for the year 1911

for the year 1911

for the year 1911

Z = Percent regulation in transformer and conductors.

V = Allowable voltage fluctuation in percent (from Chart I).

W = Kva rating of transformer.

I = Motor starting current.

E = Supply voltage {  $1\phi$  = Voltage between conductors.  
 $3\phi$  = Phase to neutral voltage = Phase to phase voltage divided by 1.73

To Find Z

1. Connect V and W. Mark intersection on A.
2. Connect A and E. Mark intersection on W.
3. Connect intersection on W with I. Read value on Z.

→ Chart III →

# EQUATIONS of CHART

$$Z = \frac{1000 V W}{I E}$$

$$B = Z I \text{ (B coincident with W)}$$

$$A = B E$$

$$A = V (1000 W)$$

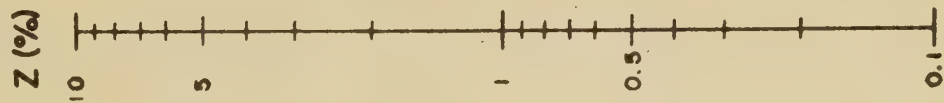
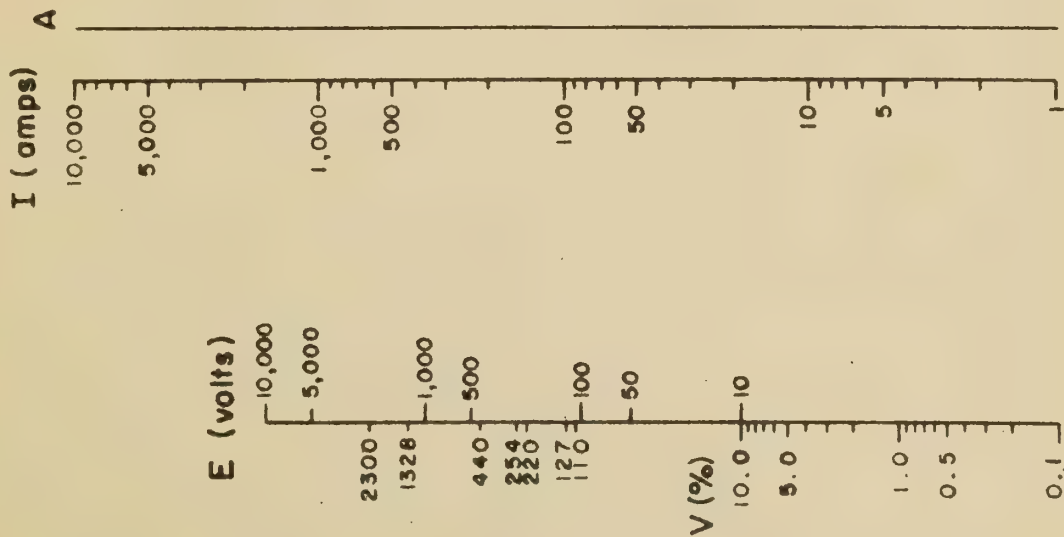






CHART IV

(a). To Determine Percent Voltage Drop in Transformer

1. Use values of  $R_T$  and  $X_T$  from Chart II.
2. Connect  $R_T$  and Power Factor. Read value of intersection on C.
3. Connect  $X_T$  and Power Factor. Read value of intersection on D.
4. Percent Voltage drop in transformer:  $Z_T = C + D$ .
5. Percent Voltage drop in secondary:  $Z_S = Z - Z_T$ .

(b). To Determine Percent Resistance Drop in Secondary or Service Circuit.

1. Connect  $Z_S$  and Power Factor
2. Intersection on  $R_S$  is percent resistance drop in secondary or service circuit.

Example: (a) From Chart II, for the transformer in the previous example,  $R_T = 2.46\%$ ,  $X_T = 1.60\%$ . Starting power factor for the motor, from Table of Starting Currents and Power factors, is 0.13.

1. Connect  $R_T = 2.46\%$  and Power Factor. Read 0.3% on C.
2. Connect  $X_T = 1.60$  and Power Factor. Read 1.4% on D.
3.  $Z_T = 1.4 + 0.3 = 1.7\%$ .
4.  $Z_S = 2.0 - 1.7 = 0.3\%$ .

(b)

1. Connect  $Z_S = 0.3\%$  and Power Factor. Read  $R_S = 2.4\%$ .

The following table shows the results of the experiments conducted on the 10th of June 1900. The results are given in the form of a table, the columns of which are headed by the names of the experiments, and the rows by the names of the substances.

Experiment	Substance	Result
1	Water	100.0
2	Alcohol	95.0
3	Oil	90.0
4	Acid	85.0
5	Base	80.0
6	Salt	75.0
7	Sugar	70.0
8	Starch	65.0
9	Gum	60.0
10	Resin	55.0

The results of the experiments show that the substances listed in the table above, when subjected to the same conditions, give rise to different results. The results are given in the form of a table, the columns of which are headed by the names of the experiments, and the rows by the names of the substances.

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$$\begin{aligned}
 & 27.1 = 10.0 + 17.1 \\
 & 10.0 = 10.0 + 0.0
 \end{aligned}$$

(a)

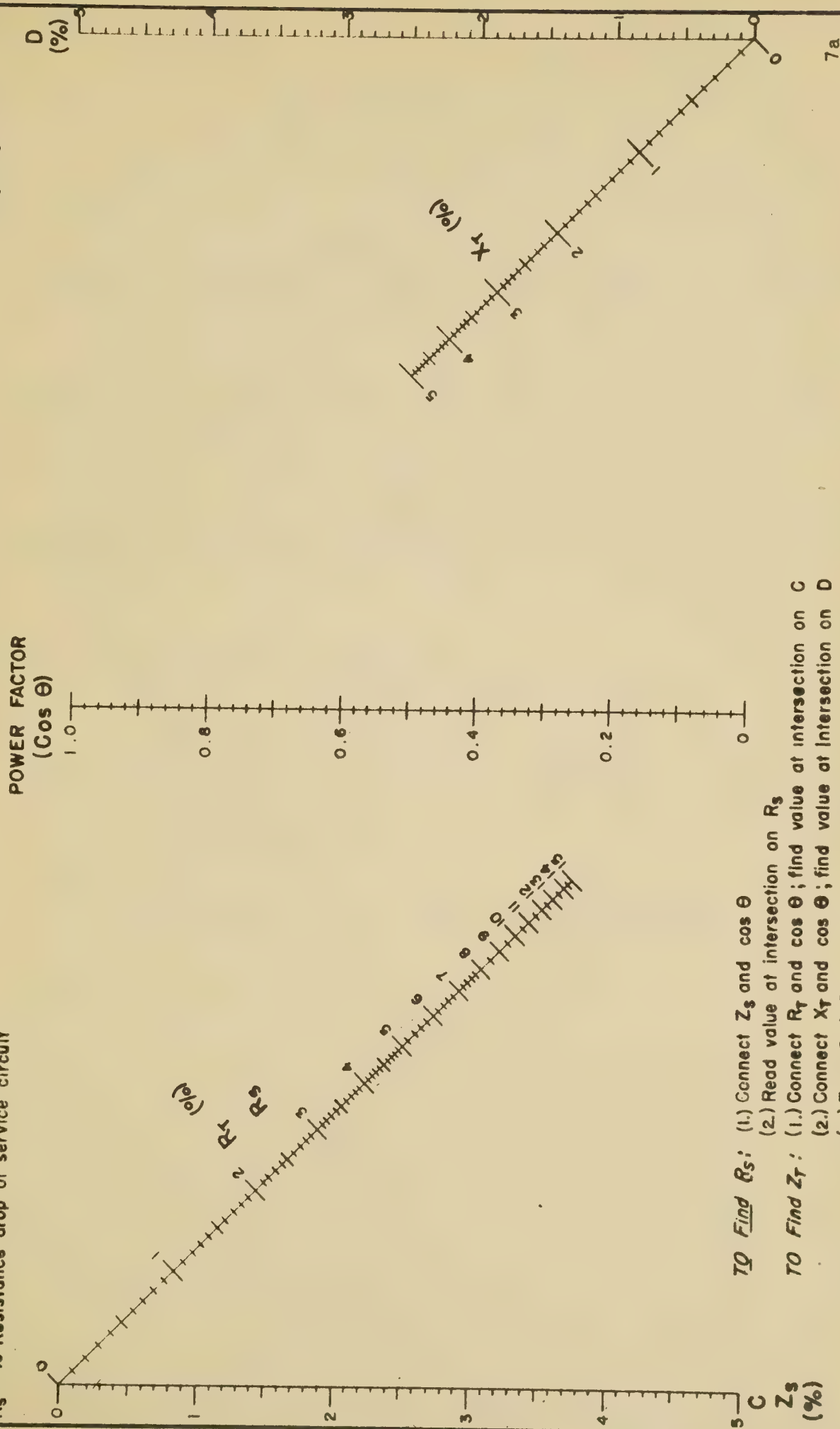
The results of the experiments show that the substances listed in the table above, when subjected to the same conditions, give rise to different results. The results are given in the form of a table, the columns of which are headed by the names of the experiments, and the rows by the names of the substances.

$R_T$  = % Resistance of transformer  
 $X_T$  = % Reactance of transformer  
 $\theta$  = Power factor angle of motor at starting  
 $Z_T$  = % Regulation of transformer  
 $Z_S$  = % Regulation of service circuit  
 $R_S$  = % Resistance drop of service circuit

# Chart IV

## EQUATIONS of CHART

1.  $C = R_T \cos \theta$
- $D = X_T \sin \theta$
- $Z_T = C + D$
2.  $Z_S = R_S \cos \theta$



- TO Find  $R_S$ :** (1.) Connect  $Z_S$  and  $\cos \theta$   
 (2.) Read value at intersection on  $R_S$
- TO Find  $Z_T$ :** (1.) Connect  $R_T$  and  $\cos \theta$ ; find value at intersection on  $C$   
 (2.) Connect  $X_T$  and  $\cos \theta$ ; find value at intersection on  $D$   
 (3.)  $Z_T = C + D$





CHART V

TO DETERMINE SECONDARY OR SERVICE CONDUCTOR SIZE

1. Connect  $R_s$  and E. Mark intersection on F.
2. Proceed from F to I. Mark intersection on  $R_s$ .
3. Connect  $R_s$  and L. Mark intersection on "r".
4. Intersection on "r" shows resistance of conductor in ohms per 1000 ft. or copper equivalent.

Example: Length of service L = 100 feet.

1. Connect  $R_s = 2.4\%$  and E = 127 volts. Mark intersection on F.
2. Proceed from F to I = 40 amps. Mark intersection on  $R_s$ .
3. Connect  $R_s$  and L = 100 ft.
4.  $r = 0.8$  ohms/1000 ft. or No. 8 copper equivalent can be used.





$R_s$  = Percent resistance drop in service conductor.

$r$  = Resistance of service conductor (OHMS/1000 FT.)

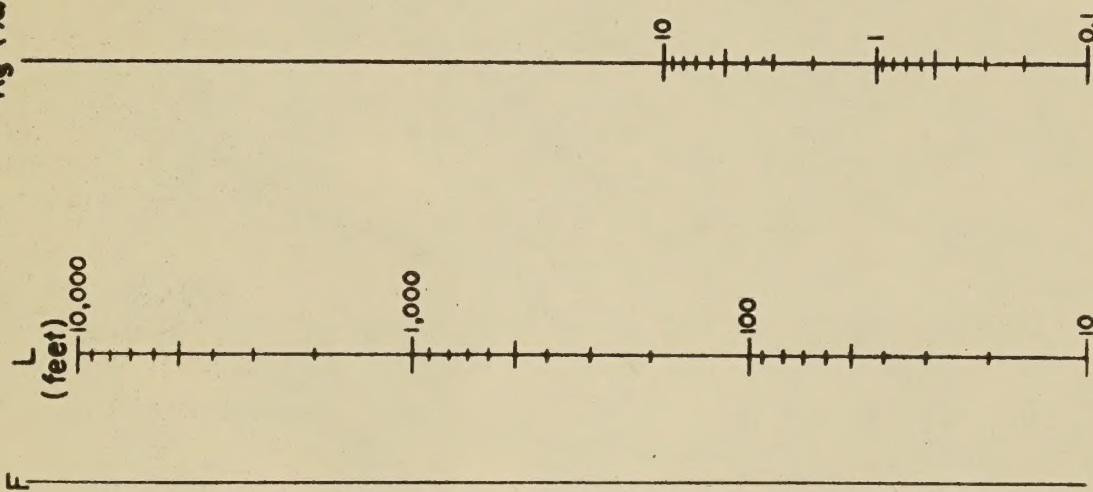
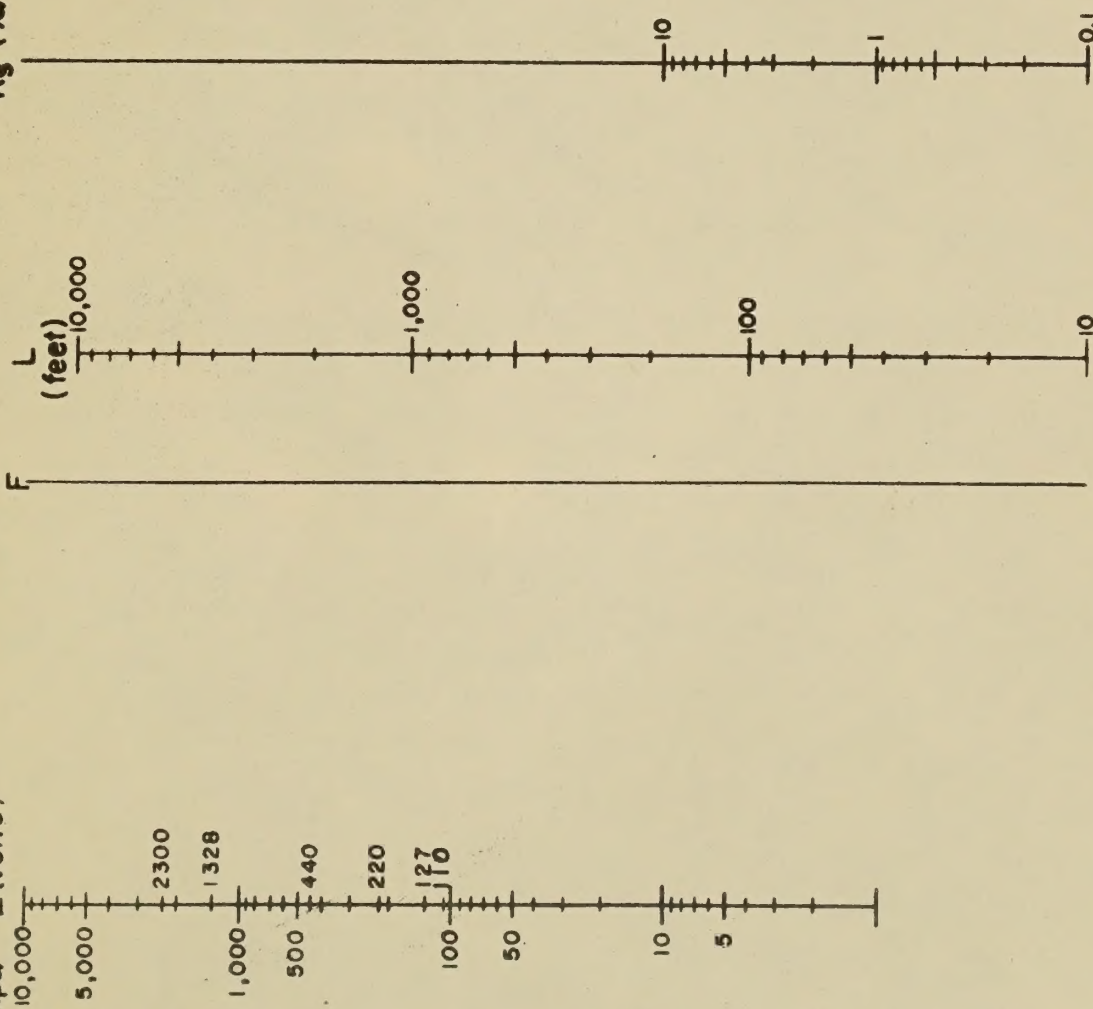
$L$  = Length of service circuit (FEET)  $\left\{ \begin{array}{l} 1 \phi = 2 \times \text{length of one conductor.} \\ 3 \phi = \text{Length of one conductor.} \end{array} \right.$

$I$  = Motor starting current.

$E$  = Supply voltage  $\left\{ \begin{array}{l} 1 \phi = \text{Voltage between conductors} \\ 3 \phi = \text{Phase to neutral voltage} \end{array} \right.$

$R_s$  (%) = Phase to phase voltage divided by 1.73

$I$  (amps)  $E$  (volts)



# TO Find Size of Service Conductor:

1. Connect  $R_s$  and  $E$ . Mark intersection on  $F$ .
2. Connect  $F$  and  $I$ . Mark intersection on  $R_s$ .
3. Connect intersection on  $R_s$  with  $L$ .

Value on " $r$ " line shows OHMS/1000 FT. or COPPER EQUIVALENT.

## EQUATIONS of CHART

$$R_s = \frac{r L I}{10 E}$$

$$R_s E = F$$

$$G I = F \text{ (G and } R_s \text{ coincident)}$$

$$r \frac{L}{10} = G$$

